EXPERT SYSTEM FOR TROUBLESHOOTING CELLULAR SITE PROBLEMS

REFERENCE TO RELATED APPLICATIONS

This application is related to the subject matter disclosed in U.S. Patent Application Serial No. ____________, entitled "Expert System for Troubleshooting Radio Frequency Performance Problems" filed on September 19, 2001, which is assigned to a common assignee and which is incorporated herein by reference.

FIELD OF THE INVENTION

This invention generally relates to cellular communications. More particularly, the present invention relates to an expert system for troubleshooting cellular network performance, such as cell site and switch problems.

BACKGROUND OF THE INVENTION

Cell site engineers solve a lot of problems pertaining to cellular sites and switches every day. When there is a problem with a cellular site or switch (such as a landline telephone switch or Mobile Switching Center (MSC)), a cell site engineer analyzes the problem, determines what is wrong and fixes the problem. The experience of the engineer is a major factor in how quickly the determination of what is wrong is made. A more experienced engineer is often able to determine what is wrong with a cell site or a switch faster than a less experienced engineer.

When an experienced cell site engineer leaves a company, the company loses a valuable asset. Less experienced engineers are no longer able to ask the experienced engineer for answers to cell site problems. Thus, there is a need for a method and system for maintaining the knowledge of experienced engineers so that the knowledge may be leveraged by other engineers. There is a further need for a computer-implemented method and system for analyzing problems with a cellular site or switch and presenting potential solutions based on historical data and collected data.

SUMMARY OF THE INVENTION

In one aspect, the present invention solves the above-described needs by providing an expert system for compiling and accessing historical data related to cellular network troubleshooting, in particular cellular site and switch troubleshooting. Data is compiled into a domain database for facts and a knowledge database for problems and potential solutions. In one embodiment of the invention, the data may be obtained by interviewing experienced engineers. Problems are typically symptoms that are experienced by a cellular telephone user or symptoms experienced at a cellular site. Potential solutions are system conditions that have been known to cause various problems and/or potential actions to be performed to remedy the problem. The problems and solutions are organized into expert system rules. An inference engine may process the rules and the facts to provide a list of potential solutions. A user can access the inference engine through a user interface. The user interface can be used to transmit facts and problems to the inference engine. The user interface can also display to the user potential solutions that are generated by the inference engine. The inference engine receives the facts and problems from the user interface and processes the input by accessing the knowledge database and the domain database. The user interface, the inference engine, the knowledge database, and the domain database, are collectively referred to herein as an expert system.

In another aspect of the present invention, a method of troubleshooting a cellular network problem is provided. The network problem and the facts regarding the problem are input. This input is sent to an inference engine which determines whether a rule is

invoked by the input. If a rule is invoked by the input, the method will output potential sources of the problem and potential solutions to the problem. If no rule is invoked, the method will add the input to a provisional rules list which may be later converted to troubleshooting rules. If the output potential sources and solutions do not solve the problem, the method can also add the input to the provisional rules list for subsequent conversion.

These and other features, advantages, and aspects of the present invention may be more clearly understood and appreciated from a review of the following detailed description of the disclosed embodiments and by reference to the appended drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an exemplary cellular operating environment.

Figure 2 illustrates an exemplary multiple cell operating environment.

Figure 3 is a block diagram illustrating an expert system for troubleshooting cellular site problems in accordance with an embodiment of the present invention.

Figure 4 is a block diagram illustrating an expert system for troubleshooting cellular site problems in accordance with another embodiment of the present invention.

Figure 5 is a block diagram illustrating a rule stored in a knowledge database in accordance with an embodiment of the present invention.

Figure 6 is a block diagram illustrating a fact stored in a domain database in accordance with an embodiment of the present invention.

Figure 7 is a flow diagram illustrating a computer-implemented method for troubleshooting a cellular network problem.

DETAILED DESCRIPTION

In one aspect, the present invention solves the above-described needs by providing an expert system for compiling and accessing historical data related to cellular network troubleshooting, in particular cellular site and switch troubleshooting. Data is compiled into a domain database for facts and a knowledge database for problems and potential solutions. In one embodiment of the invention, the data may be obtained by

interviewing experienced engineers. Problems are typically symptoms that are experienced by a cellular telephone user or symptoms experienced at a cellular site. Potential solutions are system conditions that have been known to cause various problems and/or potential actions to be performed to remedy the problem. The problems and solutions are organized into expert system rules. An inference engine may process the rules and the facts to provide a list of potential solutions. A user can access the inference engine through a user interface. The user interface can be used to transmit facts and problems to the inference engine. The user interface can also display to the user potential solutions that are generated by the inference engine. The inference engine receives the facts and problems from the user interface and processes the input by accessing the knowledge database and the domain database. The user interface, the inference engine, the knowledge database, and the domain database, are collectively referred to herein as an expert system.

In another aspect of the present invention, a method of troubleshooting a cellular network problem is provided. The network problem and the facts regarding the problem are input. This input is sent to an inference engine which determines whether a rule is invoked by the input. If a rule is invoked by the input, the method will output potential sources of the problem and potential solutions to the problem. If no rule is invoked, the method will add the input to a provisional rules list which may be later converted to troubleshooting rules. If the output potential sources and solutions do not solve the problem, the method can also add the input to the provisional rules list for subsequent conversion.

Exemplary Cellular Environment

Having briefly described an embodiment of the present invention, an exemplary operating environment for the present invention is described below in reference to Figure 1. Referring now to the drawings, in which like numerals represent like elements throughout the several figures, aspects of the present invention will be described.

Figure 1 illustrates an exemplary cellular environment **200** well-known to those skilled in the art. The environment **200** is generally a cellular telephone system for

receiving and transmitting cellular phone calls. A cellular phone **202** is transmitting a signal **204** within a cell **206**. The cell **206** is a geographic area generally defined by a boundary **208**. The cell includes an antenna tower **210** that has transmitters and receivers for transmitting and receiving signals. The transmitters on the antenna tower **210** transmit at a designated power level. Likewise, the cell phone **202** transmits the signal **204** at a designated power level. The designated power levels of the antenna tower transmitters and the cell phone **202** dictate the location of the boundary **208** of the cell **206**. Receivers on the antenna tower **210** will generally receive the signal **204** while the cell phone **202** is within the boundary **208** of the cell **206**. Generally, when the cell phone **202** leaves the boundary **208** of the cell **206**, the receiver of the antenna **210** will no longer receive the signal **204**. In one embodiment, the cell boundary **208** is substantially hexagonal in shape.

A receiver on the antenna tower **210** is generally referred to as a cell face. The antenna tower **210** may have more than one cell face, such as a cell face **212** and cell face **214**. A typical antenna tower has three cell faces, but the number of cell faces can vary. Each cell face on the antenna tower **210** is positioned so that it covers an area within the cell **206**. Depending on the positioning and the orientation of the cell face **214**, the cell face **214** will receive calls coming from a particular direction. The cell face **212** is oriented in a different position to receive calls coming from a different direction with respect to the antenna tower **210**. A variety of cell face configurations are known in the art. For example, one cell face configuration is known as the omni face, which comprises a single cell face with a coverage area of 360 degrees around the antenna tower. A common cell face configuration includes three cell faces with each cell face having a coverage area of 120 degrees around the antenna tower. Typically a structure **216** is located near the antenna tower that houses communications equipment, such as radio transmitters, radio receivers, and power supplies. The communications equipment is connected to transmitters and cell faces on the antenna tower via a communications link **218**. The structure **216** and the antenna tower **210** are commonly referred to as a base station **220**. The base station **220** is located substantially in the middle of the cell **206**.

Each cell face on the antenna tower **210** has an associated transmitter. Transmitters transmit control signals on unique control channels or frequencies that are used to send control messages to the cell phone **202**. When the cell phone **202** is in operation, the cell phone **202** searches for the strongest control signal coming from the antenna tower **210**. The receiver in the cell phone **202** locks on to the strongest control channel and begins receiving control information. The control information includes the transmission frequency at which the cell phone **202** should transmit. In the exemplary environment **200**, when the cell phone **202** begins operation, it receives the strongest control signal from a transmitter associated with the cell face **214**. Thus, as depicted in Figure 1, the signal **204** from the cell phone **202** is being received by the cell face **214**. The cell phone **202** may transmit using any of a number of communications protocols known in the art. The signal **204** will follow the protocol used by the cell phone **202**. For example, the cell phone **202** may utilize an analog protocol known as Advanced Mobile Phone System (AMPS). Alternatively, the cell phone **202** may use a digital protocol, such as Time Division Multiple Access (TDMA).

The communications equipment **216** receives the signal **204** and may demodulate the signal. The communications equipment **216** typically is operable to receive signals in a variety of formats, including AMPS and TDMA. The signal **204** is sent to a cellular processor **222** via a communications link **224**. The cellular processor **222** is typically a sophisticated computing device operable to manage cellular communications at the antenna tower **210**. For example, the cellular processor **222** can monitor the signal strength of the signal **204**. Also, the cellular processor **222** can detect when the cell phone **202** has been disconnected to terminate the call **204**. The cellular processor **222** may also facilitate billing and locating the cell phone **202**. One example of a cellular processor known in the art is the Executive Cellular Processor (ECP) manufactured by Lucent. Many other cellular processors are known in the art. The cellular processor **222** utilizes a database **226** to perform its functions. One particular function that the cellular processor **222** performs is determining which of the cell faces on the antenna tower **210** should optimally be used to receive the signal **204**.

When the cell phone initially places a call **204**, the cell phone **204** may be located in the coverage area of the cell face **214**. Thus, the cell face **214** may have been optimal at the beginning of the conversation. However, the user of the cell phone **202** may be moving while the conversation is taking place. While the cell phone **202** moves in a direction **228**, the signal strength of the signal **204** will vary with respect to the cell faces **212** and **214**. The cellular processor **222** detects the variation in signal strength of the signal **204**. As the cell phone **202** moves in the direction **228**, it moves away from the cell face **214** and closer to the cell face **212**. The cellular processor **222** detects a decrease in the signal power received by the cell face **214**. Eventually, as the cell phone **202** continues to move, signal power received by the cell face **214** will be less than a minimum required level. In response, the cellular processor **222** accesses the database (in particular a neighbor list) **226** to determine which cell face the signal **204** can be transferred to.

The cellular processor **222** accesses the neighbor list in the database **226**. The neighbor list is generally a list of cell faces to which a signal may be transferred or handed off. For example, the database **226** has a neighbor list associated with the cell face **214**. The neighbor list for cell face **214** provides a list of available cell faces where the signal **204** can be transferred. In the example shown in Figure 1, the cell face **212** is among the available cell faces given in the cell face transfer data for the cell face **214**. After the cellular processor **222** identifies the cell face **212** as the optimal cell face, the cellular processor **222** sends a message to the communications equipment **216** indicating that the cell phone **202** should begin transmitting at a frequency associated with the cell face **212**. In response to a message from the cellular processor **222**, the transmitter for the cell face **214** transmits a control signal to the cell phone **202** that instructs the cell phone to switch to a frequency associated with the cell face **212**. The process of transferring the cell phone signal **204** from the cell face **214** to the cell face **212** is extremely fast. There is no break in the conversation recognizable by the user of the cell phone **202**. The process of transferring a signal from one cell face to another is referred to as handing off the call.

Figure 2 illustrates a multiple cell operating environment **300** well-known to those skilled in the art. The environment can include one or more cells, such as cell **301**, cell **302**, cell **304**. Cells are often referred to as cellsites or simply sites. Typically, each cell has an associated cell identification number used to identify the cell. Each cell has a base station, such as base station **306**. The cell **302** has a base station **314** and cell **304** has a base station **316**. Like the base station **220** of Figure 1, the base stations **306**, **314**, and **316** each include radio equipment and an antenna tower having one or more cell faces. Cells **301**, **302** and **304** may, but do not necessarily, overlap, as shown by an overlapping region **307**. In one embodiment, the cell **301** has a coverage area defined by a substantially hexagonal boundary **308**. During operation, a cellular processor **310** communicates with the base station **306** to monitor calls within the cell **301**. Another cellular processor **312** communicates with the base station **314** and the base station **316** to monitor calls within cell **302** and cell **304** respectively. A typical cellular processor may be associated with 100 or more cells and base stations. The environment illustrated in Figure 2 is exemplary only and the systems and methods described can generally be applied to environments including hundreds of cells.

As has been discussed, cellular processors, such as cellular processor **310** and cellular processor **312** typically monitor various data about cellular phone calls, such as signal strength, cell phone location, and billing. The cellular processors **310** and **312** also transmit signals to a mobile switching center (MSC) **318**. The MSC **318** relays cell phone signals to an external network **320**, such as a telephone wireline network. The MSC **318** is a sophisticated system that is in communication with networks and switches around the world to determine an optimal route for cell phone calls to reach their destination.

In the exemplary environment **300**, a mobile communication device, such as a cell phone **322**, is shown in the cell **301** transmitting a signal **324** to the base station **306**. The signal **324** transmits voice data over a voice channel to a cell face at the base station **306**. The base station **306** receives the signal **324** and transmits it to the cellular processor **310** so that the cellular processor **310** can monitor the signal **324**. The cellular processor **310**

may also transmit the signal **324** to the MSC **318**, which may route the signal to the external network **320**. The cell phone **322** may utilize any communications technology known in the art and the signal **324** may follow any protocol known in the art. Communications technologies include, but are not limited to, Code Division Multiple Access (CDMA), Advanced Mobile Phone System (AMPS), Global System for Mobile Communications (GSM), and Time Division Multiple Access (TDMA). Preferably, the base station **306** is operable to receive any or all of the possible communications technologies. The base station is configured to each technology – the radios are either analog or digital. An analog radio cannot handle digital calls. If the radio is a TDMA radio, it will not be able to handle GSM or CDMA calls.

As shown in Figure 2, the cell phone **322** is traveling in a direction **326**. The cell phone **322** is moving in the cell **301** toward the cell **304**. As the cell phone **322** travels, it maintains communications with the base station **306** and the cellular processor **310** monitors the strength of the signal **324**. As the cell phone **322** moves farther from the base station **306**, the cellular processor **310** may detect that the strength of the signal **324** diminishes or weakens. The cell phone **307** travels through the overlapping region **307** where cell **304** and cell **301** overlap. When the signal strength of the signal **324** drops below a minimum power level, the cellular processor **310** accesses a neighbor list in a database **328** to determine an available cell face for a hand off. The database **328** contains a plurality of neighbor lists. Each neighbor list is associated with a cell face at a cell. Preferably each neighbor list has a cell identifier and a cell face identifier for the associated cell face. The cellular processor **310** reads cell face transfer data entries from the neighbor list that identify an available transfer cell face for a hand off. Handing off a call generally means transferring the call from one cell face to another cell face.

Cell face transfer data may be updated when a new cell such as cell **304** is implemented. For example, cell **304** and its associated base station **316** may be put into service after the cells **301** and **302** are operating. When the base station **316** is put into service, a plurality of new cell faces associated with base station **316** are made available to offer mobile communication service that was not existent prior to implementation of

cell **304**. As a result of the implementation of cell **304**, data in the databases **328** and **330** may be updated to reflect the addition of cell **304**. As an example, a call in cell **301** traveling into cell **304** may be handed off to a cell face of the base station **316**. The cellular processor **312** will monitor the mobile telephone user's call for various parameters including signal strength. As the traveler travels from the cell **301** toward the cell **304**, the signal strength from the call may diminish. The cellular processor **312** will send a signal to the base station **306** to initiate a hand-off to transfer the call to a cell face of the base station **316**. The cellular processor **310** accesses the cell face transfer data stored in the database **328**. The cellular processor **310** uses cell face transfer data in the database **328** to identify cell faces that are available for the call **324** to be handed-off.

An embodiment of the present invention is an expert system for troubleshooting problems in cellular environments such as those described in Figures 1 and 2. Experts systems are well-known to those skilled in the art and will be briefly described below.

Expert Systems

Conventional programming languages, such as FORTRAN and C, are designed and optimized for the procedural manipulation of data (such as numbers and arrays). Humans, however, often solve complex problems using abstract, symbolic approaches which are not well-suited for implementation in conventional languages. Although abstract information can be modeled in these languages, considerable programming effort is required to transform the information to a format usable with procedural programming paradigms.

One of the results of research in the area of artificial intelligence has been the development of techniques which allow the modeling of information at higher levels of abstraction. These techniques are embodied in languages or tools which allow programs to be built that closely resemble human logic in their implementation and are therefore easier to develop and maintain. These programs, which emulate human expertise in well-defined problem domains, are called expert systems. Expert systems are well-known to those skilled in the art. The availability of expert system tools has greatly reduced the effort and cost involved in developing an expert system.

Rule-based programming is one of the most commonly used techniques for developing expert systems. In this programming paradigm, rules are used to represent heuristics, or "rules of thumb", which specify a set of actions to be performed for a given situation. A rule is composed of an *if* portion and a *then* portion. The *if* portion of a rule is a series of patterns which specify the data which cause the rule to be applicable. The process of matching this data to patterns is called pattern matching. The expert system tool provides a mechanism, called the inference engine, which automatically matches data against patterns and determines which rules are applicable. The *if* portion of a rule can actually be thought of as the *whenever* portion of a rule because pattern matching always occurs whenever changes are made to data. The *then* portion of a rule is the set of actions to be executed when the rule is applicable. The actions of applicable rules are executed when the inference engine is instructed to begin execution. The inference engine selects a rule and then the actions of the selected rule are executed (which may affect the list of applicable rules by adding or removing data). The inference engine then selects another rule and executes its actions. The process may continue until no applicable rules remain.

Having briefly described expert systems above, a description of an expert system in accordance with an embodiment of the present invention will be described below in reference to Figure 3.

Expert System for Troubleshooting Cellular Site Problems

Referring now to Figure 3, an expert system **400** for troubleshooting cellular site problems in accordance with an embodiment of the present invention will be described. In one embodiment, the expert system **400** may be used to troubleshoot cellular site and switch (landline or MSC) problems associated with a cellular system such as the cellular operating environments illustrated in Figures 1 and 2.

For example, a cellular site problem may occur as follows. Suppose cellular customers are reporting fast busy signals while their cellular phones are operating at a certain cellular site. A cellular site engineer may be sent to look at the problem and may

determine that some of the radios at the cellular site are not working. As another example, a switch problem may be a problem in the hardware or software of the switch.

The expert system **400** comprises a user interface **420**. It should be understood that the expert system **400** is a computer-implemented system and the user interface provides a mechanism for a user to input data into the expert system and receive data from the expert system. The user interface provides for communication exchange between the system user and the expert system. Through the user interface, the user can enter relevant facts and problems and can request solutions from the expert system. In one embodiment, the user interface allows a user to type in the problems associated with a cellular site or a switch and the system will respond by displaying a solution to the problem. Of course, other input mechanisms and user interfaces well-known to those skilled in the art may be used as part of the expert system.

Facts and problems may be entered using the user interface **420** and passed to an inference engine **415**. The inference engine may be a software application that performs the inference reasoning tasks for the expert system. The inference engine **415** is the portion of the expert system **400** that contains the strategies for controlling the selection and application of rules and facts that are stored in a knowledge database **410** and a domain database **405**. The inference engine is the part of the expert system where the reasoning actually takes place. The inference engine considers the form of the problem, the theorem to be proved or the question to be answered and the relevant portions of the knowledge database and the domain database. The inference engine receives user queries, searches the database for solutions and reports the solutions back to the user through the user interface. The inference engine may also use the knowledge in the expert system's database and information provided by the user to infer new knowledge. The inference engine may be written using the PROLOG language or another well-known logic programming language.

As mentioned above, the expert system **400** also comprises a knowledge database **410** and a domain database **405**. The knowledge database **410** comprises a plurality of

rules (which are problems **407** and solutions **408** to those problems). The rules may comprise a plurality of if-then statements.

The domain database **405** is a database of facts **406**, such as facts that apply to a particular problem. For example, if a particular cell site is having problems, then a fact may be that the cellular site has three cell faces and that the cellular site has three radios. Other examples of facts are cell location, cell type, cell manufacturer, cell latitude, cell longitude, cell status, trunk group, number of radios, setup channel number, protocol version, mobile access threshold, directed retry list, handoff retry list, radio locations, radio status, just to name a few.

In one embodiment of the invention, the knowledge database and domain database are populated via a knowledge acquisition facility (KAF) (not shown). The KAF may be a software application that provides a dialogue between the expert system **400** and the human experts for the purpose of acquiring knowledge from the human experts. The KAF places this acquired knowledge in the system's knowledge database **410** and domain database **405**. For example, the KAF may ask the human expert (in this case a cell site engineer) a question such as "What are the possible sources of a fast busy signal when a cellular site has three faces?". The KAF will then use the responses from the human expert to formulate a number of if-then statements (rules) which are stored in the knowledge database. The KAF may also use the fact scenario (that the cellular site has three faces) to populate the domain database. In another embodiment, domain and knowledge databases may also be created by interviewing experienced engineers regarding problems they have solved over the years and the solutions they found. Instead of a KAF, a Knowledge Engineer will interview the cell site engineers about their experiences solving problems. The cell site engineers will give the Knowledge Engineer a list of problems that they have solved (problems and solutions). The Knowledge Engineer uses the problems and solutions to store rules in the expert system. The Knowledge Engineer may use LISP, PROLOG, or any other Artificial Intelligence Languages to write a computer software program to help store the rules. The inference engine 415 may also be built by the Knowledge Engineer.

Referring now to Figure 4, an illustration of an expert system **450** for troubleshooting cellular site problems in accordance with another embodiment of the present invention will be described. The expert system **450** comprises a knowledge database **410**, a domain database **405**, a user interface **420** and an inference engine **415** as described in reference to Figure 3. However, the expert system **450** also comprises a provisional rules list **425**. After the databases are constructed initially, more facts and rules may be added as new problem solutions are found. Also, it may be necessary to modify the existing rules in some cases. The provisional rules list provides a means for storing facts and problems for which solutions have not been found yet. As solutions to these problems are found, the problems and solutions may be converted to rules and stored in the knowledge database and the facts associated with the rules may be stored in the domain database.

Referring now to Figure 5, an illustration of a rule **500** stored in the knowledge database **410** will be described. The rule **500** comprises an if-then statement. The if portion of the statement corresponds to the problem **407**, such as "cell phone user experiences fast busy". The then portion of the statement corresponds to potential solutions or potential problem sources (**408**) such as "antennas in the cell are down, cell site is down completely, etc." It should be understood that the rule **500** may comprise a plurality of nested if-then statements to provide the logic desired.

Referring now to Figure 6, an illustration of a fact **406** stored in the domain database **405** will be described. The fact **406** lists data that may be used by the expert system in association with a rule to determine a potential solution or problem source for the problem.

Method for Troubleshooting a Cellular Network Problem

Referring now to Figure 7, a flow diagram illustrating a computer-implemented method **700** for troubleshooting a cellular network problem in accordance with an embodiment of the present invention will be described. In a preferred embodiment, the method is implemented using an expert system such as the expert system **400** (Fig. 3) or expert system **450** (Fig. 4).

The method **700** begins at start step **705** and proceeds to step **710** where a user inputs (using the user interface) a symptom (or problem) that is being experienced at the cellular site or switch. In one embodiment of the invention, the user may enter the symptom into a field in the user interface. In another embodiment, the user may select a symptom from a list of symptoms. In yet another embodiment, the user may enter the symptoms in a natural language format. For example, the user may enter that "the cell user is experiencing a fast busy signal". Of course, other well-known user interface techniques may also be used to enter the symptom at step **710**. The method then proceeds to step **715**.

At step **715**, the user inputs (using the user interface) facts regarding the cellular site or switch. The method then proceeds to step **720**.

At step **720**, the symptoms and facts input at steps **710** and **715** are sent to the inference engine.

At decision step **725**, the inference engine determines whether a rule is invoked by the symptom and facts inputs. The inference engine may be a computer program that takes users input about a problem, looks over the knowledge database for answers and reports the answers back to the user. If no rule is invoked, then the method **700** proceeds to step **750** where the symptoms and facts input are added to the provisional rules list. However, if a rule is invoked at decision step **725**, then the method **700** proceeds to step **730**.

At step **730**, the potential sources of the problem and/or potential solutions to the problem are output to the user interface. The method then proceeds to decision step **735**.

At decision step **735**, a prompt in the user interface asks the user whether the problem was solved. If so, then the method ends at step **799**. However, if the problem was not solved, then the method proceeds to decision step **740**.

At decision step **740**, a prompt in the user interface asks the user whether the symptoms and facts input should be added to the provisional rules list. If not, then the method ends at step **799**. However, if the user does wish to add the symptoms and facts

to the provisional rules list, then the method proceeds to step **750** where the symptoms and facts are added to the provisional rules list.

The method then proceeds to decision step **755** where it is determined whether the user has entered a potential solution to the problem/source of the problem. If not, then the method ends at step **799**. However, if the user has determined a potential solution to the problem/source of the problem, then the method proceeds to step **760**.

At step **760**, then user inputs the potential solution/source of the problem and the provisional rule is converted to a troubleshooting rule in the knowledge database, such as by a knowledge engineer converting the rule. The method then ends at step **799**.

Although the present invention has been described above as implemented in preferred embodiments, it will be understood that alternative embodiments will become apparent to those skilled in the art to which the present invention pertains without departing from its spirit and scope. Accordingly, the scope of the present invention is defined by the appended claims rather than the foregoing description.